NUREG-1003

Draft Environmental Statement
related to steam generator repair at H. B. Robinson Steam Electric Plant Unit No. 2

Docket No. 50-261

Carolina Power and Light Company

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

September 1983

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This draft environmental statement was prepared by the U.S. Nuclear Regulatory Commission staff. This statement contains an environmental evaluation of the proposed steam generator repair program for H. B. Robinson Steam Electric Plant Unit No. 2.

For further information regarding this environmental statement, contact:

Glode Requa, Project Manager
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555
(301) 492-7877

Comments on this draft statement must be received by the Director, Division of Licensing, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC 20555, by October 31, 1983, to be assured that they are taken into account in the preparation of the final environmental statement. Because of the restraints of time, an extension cannot be granted.

ABSTRACT

The staff has considered the environmental impacts and economic costs of the proposed steam generator repair at the H. B. Robinson Steam Electric Plant Unit No. 2 along with reasonable alternatives to the proposed action. The staff has concluded that the proposed repair will not significantly affect the quality of the human environment and that there are no preferable alternatives to the proposed action. Furthermore, any impacts from the repair program are outweighed by its benefits.

SUMMARY

In letters dated July 1, 1982 and September 16, 1982, Carolina Power and Light Company (CP&L) proposed to repair the steam generators in H. B. Robinson Steam Electric Plant Unit 2 (HRB-2, or the plant) (Section 2). The Nuclear Regulatory Commission staff (the staff) determined that the proposed program would require amending the CP&L operating licenses for the plant, and on November 24, 1982 a Notice of the Proposed Issuance of Amendment to the license was published in the Federal Register (47 FR 53157). Petitions for leave to intervene were filed and one was granted in connection with this proposed action.

On March 24, 1983 a special prehearing conference was held at Florence, South Carolina. On April 12, 1983, the Atomic Safety and Licensing Board issued a Memorandum and Order which ordered, among other things, that the petitioner, Hartsville (Group), be admitted as a party intervenor in the proceeding. On June 10, 1983, the Director, Office of Nuclear Reactor Regulation, directed that an Environmental Impact Statement (EIS) be prepared.

The primary impact in this environmental review is the occupational radiation exposure that the HBR-2 repair program will entail (Section 4.1.1.1).

The staff comparatively evaluated the environmental impacts of the proposed repair program (replacing the lower assemblies of the steam generator) and the following alternatives to the repair and disposal programs.

(1) Entirely replacing the steam generator (Section 5.1)

(2) Retubing the steam generators in place (Section 5.2)

(3) Sleeving the steam generators (Section 5.3)

(4) Shutting down H. B. Robinson Steam Electric Plant Unit 2 (no change) (Section 5.4)

(5) Immediate intact offsite shipment without decontamination (Section 5.6)

(6) Immediate intact offsite shipment with decontamination (Section 5.6)

(7) Long-term intact onsite storage (Section 5.6)

(8) Immediate cut-up and offsite shipment with decontamination (Section 5.6)

(9) Immediate cut-up and offsite shipment without decontamination (Section 5.6)

The staff has concluded that the proposed program will not significantly affect the quality of the human environment. Furthermore, the staff found none of the alternatives to be obviously superior to the proposed program. The staff has also concluded that any impacts from the proposed repair program are outweighed by its benefits (Section 6).

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ALARA	as low as is reasonably achievable
AVT	all-volatile treatment
BEIR	Biological Effects of Ionizing Radiation (Advisory Committee of the National Academy of Sciences)
BWR	boiling water reactor
CFR	Code of Federal Regulations
CP&L	Carolina Power and Light Company
DER	design electrical rating
EFPM	effective full-power months
EPRI	Electric Power Research Institute
FES	final environmental statement
FPL	Florida Power and Light Company
FR	Federal Register
HBR-2	H. B. Robinson Steam Electric Plant Unit No. 2
ICRP	International Commission on Radiological Protection
NCRP	National Council on Radiation Protection and Measurement
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
PNL	Pacific Northwest Laboratories
PWR	pressurized water reactor
SG	steam generator
SGLA	steam generator lower assembly
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation

1 PURPOSE OF THIS ENVIRONMENTAL STATEMENT

By letter dated July 1, 1982, Carolina Power and Light Company (CP&L, or the licensee) submitted a letter of intent to repair the three steam generators (SGs) at the H. B. Robinson Steam Electric Plant Unit No. 2 (HBR-2). The letter briefly described CP&L's intended program and informed the NRC that a Preliminary Steam Generator Repair Report would be submitted on September 1, 1982. CP&L made a determination that "this repair will be an allowable activity under 10 CFR 50.59, not requiring NRC issue of a Safety Evaluation Report." CP&L made this determination based on the fact that NRC review and evaluation of previous SG replacements had shown the absence of unreviewed safety issues. The Preliminary Repair Report was submitted by CP&L letter dated September 16, 1982. By letter dated November 18, 1982, the NRC staff informed CP&L that the staff first had to review and approve these repairs, and that the CP&L letter of July 1, 1982 as supplemented by the letter dated September 16, 1982 was considered as an application for a license amendment. The staff's letter also notified CP&L that proposed issuance of amendments associated with this action were being published in the Federal Register. Publication in the Federal Register took place November 24, 1982 (47 FR 53157).

On January 6, 1983, CP&L submitted its report entitled "Final Steam Generator Repair Report." This report has been supplemented by Revision 1, dated March 31, 1983, and supplemental material to Revision 1, May 5, 1983. The report describes a proposed program to repair the three steam generators at HBR-2 by replacing the lower assembly, including the tube bundles, of each generator.

On June 10, 1983, the Director, Office of Nuclear Reactor Regulation, directed that an Environmental Impact Statement (EIS) be prepared for the amendment application regarding the repair of the HBR-2 steam generators.

2 BACKGROUND

The steam generator repair program proposed by CP&L is essentially identical to the steam generator repairs completed by the Florida Power and Light Company (FPL) for Turkey Point Units 3 and 4, and essentially similar to the repairs conducted at Surry Power Station Units 1 and 2. Each of the plants contain two Westinghouse three-loop pressurized water reactors (PWRs). Each plant began operation using a sodium phosphate secondary water chemistry treatment: H. B. Robinson Unit 2 in June 1971 and Turkey Point in late 1974. The Turkey Point repair program was approved June 24, 1981 and repair commenced in June 19, 1981 for Unit 3 and was completed April 7, 1982. Unit 4 repair commenced October 16, 1982 and was completed May 16, 1983.

2.1 History of Steam Generator Operation

H. B. Robinson Steam Electric Plant Unit No. 2 (HBR-2) began commercial operation on March 7, 1971. Like almost all units with U-tube design steam generators, it began operation using a sodium phophate secondary water chemistry treatment. This treatment was designed primarily to remove precipitated or suspended solids by blowdown and was successful as a scale inhibitor.

Eddy current testing began in 1972, when steam generator tube leaks occurred. Upon determining the cause to be caustic corrosion, feedwater chemistry specifications (the sodium to phosphate ratios) at HBR-2 were adjusted to ensure that acceptable caustic conditions would be maintained in the steam generator.

HBR-2 and San Onofre Unit 1 had not experienced phosphate wastage at the rate experienced at other plants using phosphate chemistry during the period when the other PWRs converted to all-volatile-treatment (AVT) chemistry control in the secondary system. Therefore, in 1975, HBR-2 chose not to switch from a sodium phosphate treatment to an AVT chemistry for the steam generator secondary coolant, since the steam generator condition would not be significantly improved and might possibly be degraded. Instead, actions were taken such as "sludge lancing" during outages to remove sludge buildup occurring on the steam generator tube support sheet and condenser air inleakage was more stringently monitored and controlled. Eddy current inspection of tubes during outages was continued to determine tube condition and to monitor the status of tube degradation.

Based on Electric Power Research Institute (EPRI) recommendations, HBR-2 continued to monitor condenser inleakage strictly and to make other modifications to the system to assist in alleviating the inleakage problem. Among these modifications the feedpoint for hydrazine, an oxygen scavenger, and injection into the feedwater system were changed.

In 1980, HBR-2 began experiencing problems with stress corrosion cracking in tubes near the tubesheets. As a result of a high level of stress corrosion cracking activity above the tubesheet area observed during the August 1981 eddy current inspection, licensing conditions were imposed for the balance of cycle 8 operations. The conditions included periodic steam generator primary to secondary hydrostatic tests and more stringent limits on allowable primary to secondary leakage (a definition of terms and general explanation of the corrosion phenomena discussed here may be found in NUREG-0886, "Steam Generator Tube Experience," February 1982).

HBR-2 shut down as a result of a 0.3-gpm leak on July 30, 1981. Inspection of the leaking tube revealed that a through-wall stress corrrosion crack above the top of the tubesheet elevation was the source of the leak. In addition, evidence of general intergranular attack was observed below the top of the tubesheet in the crevice region. The crack above the tubesheet had an axial orientation and was approximatley 0.8 in. long. The low leakage rate has been attributed to the restraining effect of the hard sludge on the tube, a phenomenon similar to one that was observed previously at San Onofre Unit 1. In August 1981, based on advice from Westinghouse and from data obtained by EPRI that correlated temperature to the corrosion phenomenon, HBR-2 began operating at a 50% power level to reduce the hot-leg temperature. In November 1981, HBR-2 began operating on an NRC-approved reduced T_{ave} program to reduce stress corrosion cracking.

An eddy current inspection performed during the refueling operation for cycle 9 core reload, during March and April 1982, indicated that the reduced temperature operation since November 1981 had been successful in sharply reducing the stress corrosion cracking activity above the tubesheet. However, the inspection also indicated an acceleration of phosphate wastage corrosion during the reduced power operating cycle (cycle 8). Therefore, an additional operating limit of 6 effective full-power months (EFPM) was imposed on the plant. After 6 EFPM operation, the unit was to be shut down for a steam generator inspection to ensure that further progression of wastage did not become excessive. Since the reduced temperature operation was successful in reducing stress corrosion cracking, the licensing condition for primary to secondary steam generator hydrostatic testing imposed in 1980 was removed.

The operation of HBR-2 continues to be subject to operating restrictions such as reduced power level, stringent limits for primary to secondary leakage, and additional inspection and reporting requirements in the event that the unit is shut down because of leakage in excess of the limits in the Technical Specification.

The licensee took additional actions to assist in controlling tube deterioration. These actions included removing of copper from the feedwater system and condenser, improving inspections to identify and correct existing and potential leakage paths into the condenser, and relocating the condensate makeup line to the hotwell to provide better oxygen removal. The May 1983 eddy current inspection was performed on 100% of the unplugged tubes. As a result of this inspection, 16 tubes were plugged in the A steam generator, 139 in B, and 208 in C. In 1982 a total of 196 tubes were plugged; in 1981, 401 tubes; in 1980, 314 tubes; in 1979, 38 tubes; and prior to 1979, 324 tubes.

2.2 Reasons for Steam Generator Repair

The steam generators at Carolina Power and Light Company's (CP&L's) H. B. Robinson Unit 2 have experienced significant corrosion-related phenomena that require periodic inspection and plugging of steam generator tubes to ensure their continued safe operation as discussed in Section 2.1 above. At the present time, HBR-2 is being operated at reduced power to retard the rate of SG tube degradation. Projections of industry experience and CP&L experience at HBR-2 indicate the possibility of increasingly frequent inspection intervals and a permanent reduction of unit power. As of May 1983, tube plugging for various reasons has resulted in removing about 16.7% of the steam generator tubes from continuing service at the HBR-2 plant.

Because of the continuing tube degradation problems, the certainty of additional tube plugging that will result in continuing power derating, and the economic considerations for operating with substantially reduced heat transfer capacities on Unit 2, CP&L submitted a proposal for the replacement of the degraded portions of the steam generators. This replacement would increase availability and reliability of the plant and permit the plant to return to full power operation.

2.3 Staff Environmental Review

Information useful to the environmental review was also obtained from the updated NRC staff safety evaluation report (NUREG/CR-1595) on the repair project, particularly the sections evaluating (1) the effects of steam generator design changes, (2) the radiological and ALARA (as low as reasonably achievable) considerations, and (3) the radiological consequences of postulated accidents.

2.4 Major Environmental Impact

The major environmental impact is the occupational radiation exposure associated with the proposed repair of the degraded steam generators of the H. B. Robinson Steam Electric Plant Unit No. 2.

3 DESCRIPTION AND SCOPE OF THE PROPOSED REPAIR

A drawing showing the principal parts of a typical steam generator is presented in Figure 3.1. Figure 3.2 shows the regions where the main cuts are proposed to remove the degraded steam generator. The figure also shows the radiation levels in the work area. A brief description of the CP&L proposed repair procedure follows.

3.1 Changes

A number of changes have been made in the materials, the design, and the operating procedure for the replacement steam generators to ensure that the corrosion and denting problems will not recur. Among the more important of these changes are

(1) using all-volatile-treatment chemistry control in the secondary system from the beginning of operation

(2) changing the flow distribution baffle design to produce greater lateral flow across the surface of the tubesheet to minimize the number of tubes exposed to sludge

(3) improving lateral blowdown design to give 2-in. internal blowdown pipes for continuous blowdown providing for constantly removing impurities from the secondary water systems and steam generators

(4) minimizing the potential for buildup impurities forming in the crevice region by means of full depth expansion of tubes in the tubesheet (The original steam generators were only partially expanded in this region.)

(5) selecting corrosion-resistant material for the support plate using SA-240 type 405 ferritic stainless steel to reduce corrosion in the crevices between the tube and tube support plate, thus minimizing tube denting

(6) thermally treating the Inconel 600 heat exchanger tubes for better corrosion resistance

(7) using a broached hole pattern with a quatrefoil design in the support plates rather than separately drilled flow holes to minimize the accumulation of corrosion products where the tubes pass through the plates

Other plant support systems either have been accomplished or will be accomplished to increase the operating reliability and flexibility and to improve the secondary side resistances to corrosion and consequently minimize the potential for future repairs as a result of corrosion product buildup. Some of the more important changes are:

(1) Remove copper-based alloys condenser tube and replace with Type 439 stainless steel.

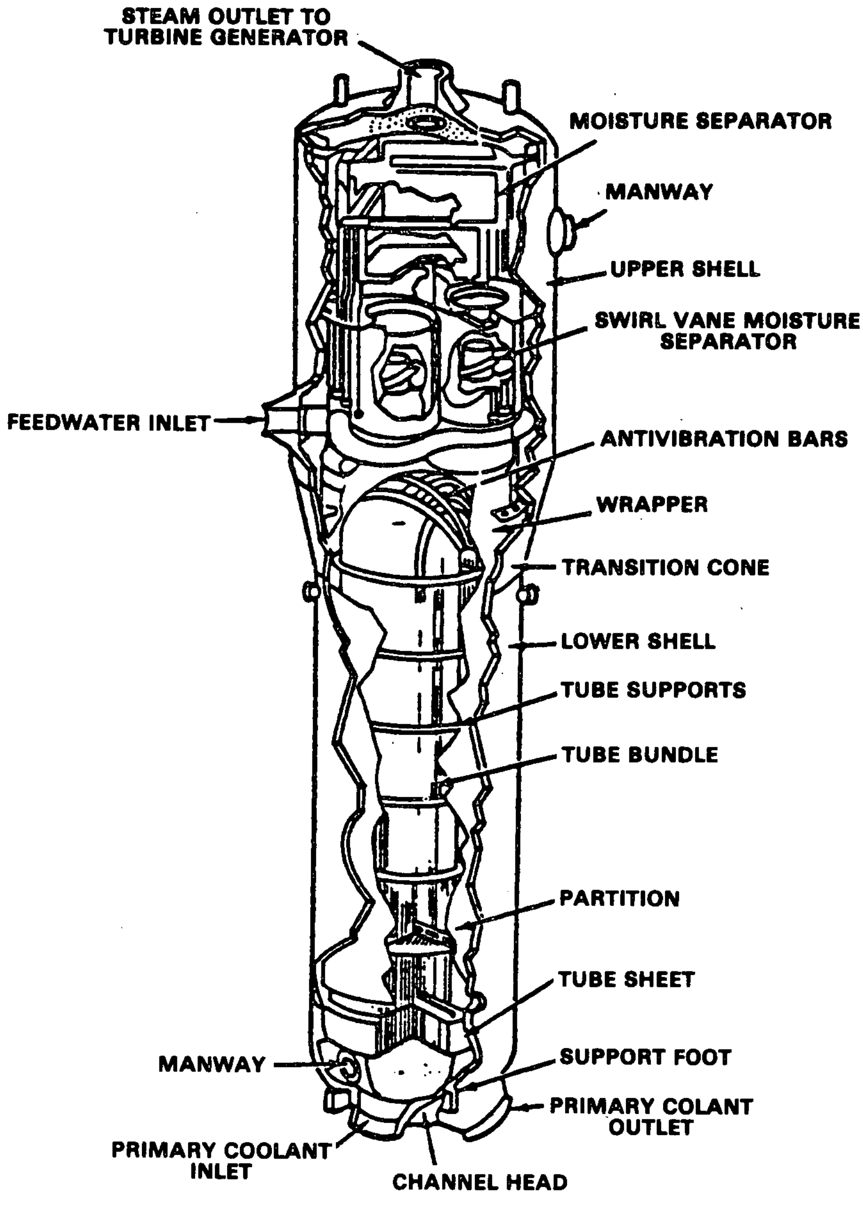

Figure 3.1 Typical steam generator

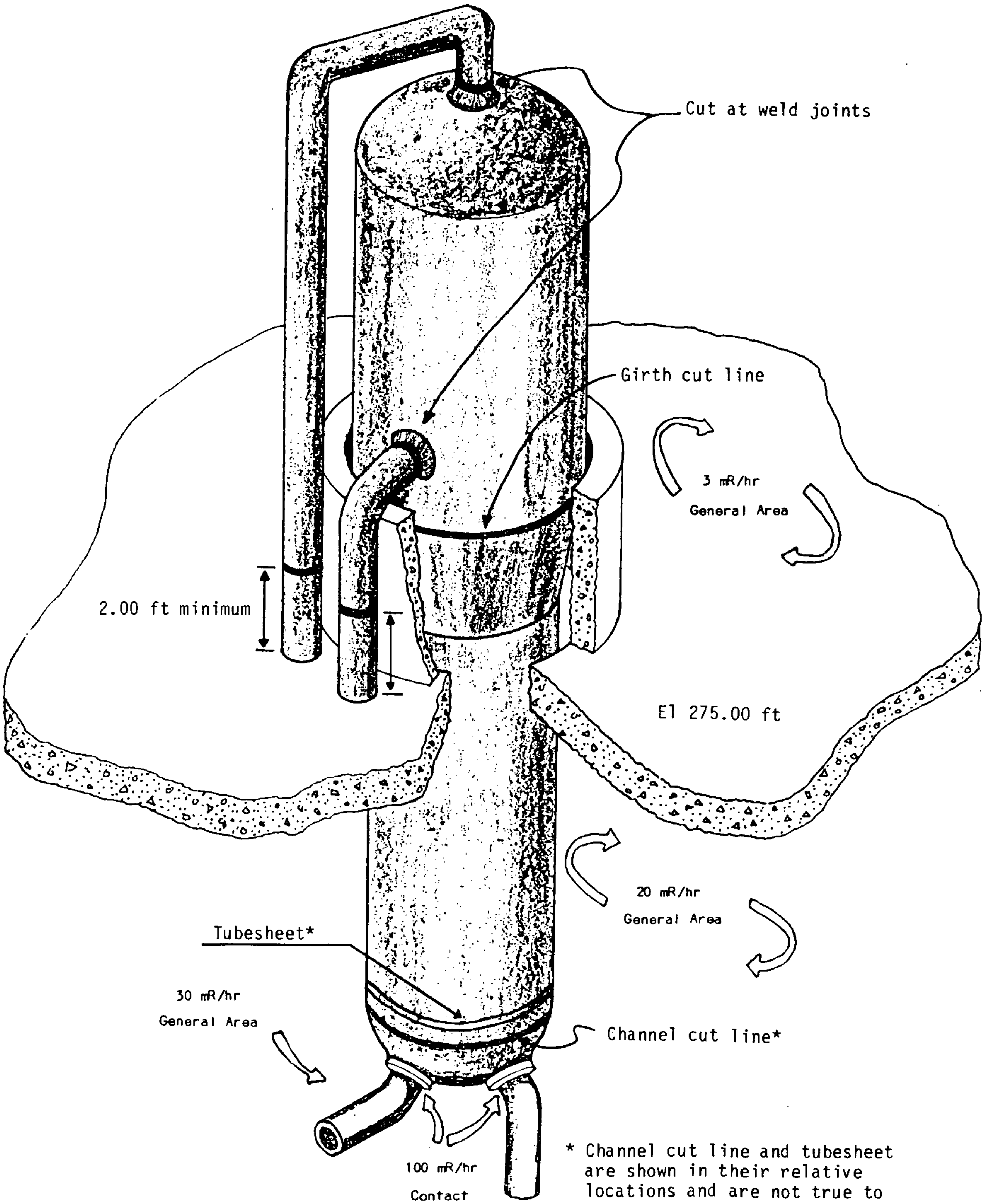

Figure 3.2 Dose rates around steam generator and proposed cuts

(2) Replace feedwater headers with stainless steel tubes.

(3) Replace moisture separator reheater tube bundles with stainless steel.

3.2 Steam Generator Repair

CP&L is planning to repair all three steam generators at HBR-2. The repair will consist of replacing the lower assembly of each steam generator including the shell and the tube bundle and refurbishing and partially replacing the steam separation equipment in the upper assembly. The old lower assembly will be removed from the containment building through the existing equipment hatch and transported to a special storage facility that will be constructed on the HBR-2 site. The new steam generators will be received by rail, and will be stored west of the existing storage area in the yard.

Before initiating the repair work, the unit will be shut down and all systems will be placed in condition for long-term layup. The reactor vessel head will be removed for defueling. All of the normal procedures for fuel cooling and fuel removal will be followed. The fuel will be removed from the reactor and placed in the spent fuel storage facility, and then the reactor vessel head will be replaced. The equipment hatch will be opened and access control will be established. Two to three feet of the biological shield wall will be removed to provide access to the steam generator.

During this preparatory work, the cutting of the system piping will begin. This will include cutting and removal of sections of steam lines, feedwater lines, and miscellaneous smaller lines for the service air and water and the instrumentation systems. The steam generator will then be cut at the transition cone, and the steam dome will be removed and will be refurbished outside containment in a temporary protective enclosure. After the channel cut at the bottom (see Figure 3.2), the lower assembly will be lifted from its support to the working level where it will be welded shut.

Following this, the steam generator lower assembly will be lowered and placed in position on a transport mechanism. This mechanism will carry the assembly through the equipment hatch. A mobile crane will lift the lower assembly onto a transporter that will carry it to the steam generator storage facility on the site. The other two lower assemblies will be lifted from their location, welded shut, and lowered through the same hatch where the first steam generator was removed.

After all three lower assemblies have been removed and stored, their replacements will be transported from the temporary storage location to the equipment hatch. The same machinery used to remove the lower assemblies will be used to install the new assemblies in their cubicles. The steam generator's lower assembly will be reinstalled and rewelded to the old bottom section. The upper assembly with its refurbished internals will be mounted on the lower assembly. After welding the two assemblies together, the piping will be reconstructed.

3.3 Post-Installation Testing

Once the major repair activities have been completed, cleaning, hydrostatic testing, baseline inservice inspections, and preoperational testing of instruments, components, and systems will follow. The reactor will then be refueled and startup tests will be performed. The performance of the repaired steam generators will be tested for moisture carryover and verification of thermal and hydraulic characteristics.

4 ENVIRONMENTAL IMPACTS OF THE STEAM GENERATOR REPAIR PROJECT

4.1 Radiological Assessment of Doses Due to Repair

4.1.1 Occupational Exposure

The Carolina Power and Light Company (CP&L, or the licensee) has estimated that the occupational exposure from the proposed steam generator repair at the H. B. Robinson Steam Electric Plant Unit No. 2 (HBR-2) will be about 2120 person-rems (CP&L, 1983). On the basis of the staff's review of the licensee's report, the staff concludes that the licensee's estimate of 2120 person-rems to the work-force is a reasonable estimate of the expected dose.

4.1.1.1 Environmental Significance of Occupational Exposure

To determine the relative environmental significance of the estimated occupational dose for the repair, the staff has compared that dose with the doses experienced at modern pressurized water reactors (PWRs). In addition, the staff has compared the estimated risk to nuclear power plant workers with published risks for other occupations.

Most of the doses to nuclear plant workers result from external exposure to radiation emitted by radioctive materials outside of the body, rather than from internal exposure to inhaled or ingested radioactive materials. Experience has shown that the total annual dose to nuclear plant workers varies from reactor to reactor and from year to year. Recently licensed 1000-MWe PWRs are designed in accordance with the post-1975 regulatory requirements and guidelines that place increased emphasis on maintaining occupational exposure at nuclear power plants as low as is reasonably achievable (ALARA). These requirements and guidelines are outlined respectively in 10 CFR 20, Standard Review Plan Chapter 12 (NUREG-0800), and Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable."

The NRC staff reviewed the licensee's proposed implementation of these requirements and guidelines for the repair work. The results of that review will be reported in the staff's Safety Evaluation Report (NUREG-1004).

Table 4.1 shows the occupational dose history for HBR-2. With the addition of 2120 person-rems for the repair, the average annual dose for the 11 years of dose history at HBR-2 (1971 through 1982) will be approximately 1075 person-rems.

Average collective occupational dose information of 239 PWR reactor years of operation is available for those plants operating between 1974 and 1981. (The year 1974 was chosen as a starting date because the dose data for years before 1974 are primarily from reactors with average rated capacities below 500 MWe.) These data indicate that the average reactor annual collective dose at PWRs has been about 500 person-rems, with some plants experiencing an average plant lifetime annual collective dose to date as high as 1400 person-rems (NUREG-0713). These dose averages are based on widely varying yearly doses at PWRs. For

Table 4.1 Annual collective occupational dose at the H. B. Robinson Steam Electric Plant Unit No. 2

Year	Reported collective occupational dose* (person-rems)
1972	215
1973	695
1974	672
1975	1142
1976	715
1977	455
1978	963
1979	1188
1980	1852
1981	733
1982	1426
Average	914

*NUREG-0713

example, for the period mentioned above, annual collective doses for PWRs have ranged from 18 to 5262 person-rems per reactor. However, the average annual dose per nuclear plant worker of about 0.8 rem (NUREG-0713) has not varied significantly during this period. The worker dose limit, established by 10 CFR 20, is 3 rems per quarter, if the average dose over the worker lifetime is being controlled to 5 rems per year, or 1.25 rems per quarter if it is not.

The wide range of annual collective doses experienced at PWRs in the United States results from a number of factors, such as the amount of required maintenance and the amount of reactor operations and inplant surveillance. Because these factors can vary widely and unpredictably, it is impossible to determine in advance a specific year-to-year annual occupational radiation dose for a particular plant over its operating lifetime. There may on occasion be a need for relatively high (with respect to the average annual collective dose) collective occupational doses, even at plants with radiation protection programs designed to ensure that occupational doses will be kept ALARA.

4.1.1.2 Risks Attributable to Occupational Exposure

The average annual dose of about 0.8 rem per nuclear-plant worker at operating BWRs (boiling water reactors) and PWRs (pressurized water reactors) has been well within the limits of 10 CFR Part 20. However, for impact evaluation, the NRC staff has estimated the risk to nuclear-power-plant workers and compared it in Table 4.2 to published risks for other occupations. On the basis of comparisons, the staff concludes that the risk to nuclear-plant workers from plant operation is comparable to the risks associated with other occupations.

In estimating the health effects resulting from occupational radiation exposures as a result of this steam generator repair program, the NRC staff used somatic (cancer) and genetic risk estimators that are based on widely accepted scientific information. Specifically, the staff's estimates are based on information

Table 4.2. Incidence of job-related mortalities

Occupational group	Mortality rates (premature deaths per 10^5 person-years)
Underground metal miners*	~1300
Uranium workers*	420
Smelter workers*	190
Mining**	61
Agriculture, forestry, and fisheries**	35
Contract construction**	33
Transportation and public utilities**	24
Nuclear-plant workers†	23
Manufacturing**	7
Wholesale and retail trade**	6
Finance, insurance, and real estate**	3
Services**	3
Total private sector**	10

*U.S. Department of Health, Education and Welfare, 1972.

**U.S. Bureau of Labor Statistics, 1978.

†The nuclear-plant worker's risk is equal to the sum of the radiation-related risk and the nonradiation-related risk. The estimated occupational risk associated with the industry-wide average radiation dose of 0.8 rem is about 11 potential premature deaths per 10^5 person-years due to cancer, based on the risk estimators described in the following text. The average nonradiation-related risk for seven U.S. electrical utilities over the period 1970-1979 is about 12 actual premature deaths per 10^5 person-years as shown in Figure 5 of the paper by R. Wilson and E. S. Koehl, 1980. (Note that the estimate of 11 radiation-related premature cancer deaths describes a potential risk rather than an observed statistic.)

compiled by the National Academy of Science's Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR, 1972; NUREG-0713). The estimates of the risks to workers and the general public are based on conservative assumptions (that is, the estimates are probably higher than the actual number). The following risk estimators were used to estimate health effects: 135 potential deaths from cancer per million person-rems and 258 potential cases of all forms of genetic disorders per million person-rems. The cancer-mortality risk estimates are based on the "absolute risk" model described in the BEIR, 1972 report (BEIR I). Higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. Use of the "relative risk" model would produce risk values up to about four times greater than those used in this report. The staff regards the use of the "relative risk" model values as a reasonable upper limit of the range of uncertainty. The lower limit of the range would be zero because there may be biological mechanisms that can repair damage caused by radiation at low dose and/or dose rates. The number of potential nonfatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers, according to the 1980 report of the National Academy of Science's Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR III).

Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders per million person-rems (BEIR I, 1972). The value of 258 potential cases of all forms of genetic disorders is equal to the sum of the geometric means of the risk of specific genetic defects and the risk of defects with complex etiology.

The preceding values for risk estimators are consistent with the recommendations of a number of recognized radiation-protection organizations, such as the International Commission on Radiological Protection (ICRP, 1977), the National Council on Radiation Protection and Measurement (NCRP, 1975), the National Academy of Sciences (BEIR III, 1980), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1977).

The risk of potential fatal cancers in the exposed workforce population at HBR-2 and the risk of potential genetic disorders in all future generations of this workforce population, are estimated as follows: multiplying the plant-worker-population dose (about 2120 person-rems) by the risk estimators, the staff estimates that about 0.3 cancer death may occur in the total exposed population and about 0.6 genetic disorder may occur in all future generations of the same exposed population. The value of 0.3 cancer death means that the probability of one cancer death over the lifetime of the entire work force as a result of the repair is about one chance in 3. The value of 0.6 genetic disorder means that the probability of 1 genetic disorder in all future generations of the entire work force as a result of the repair project is about 6 chances in 10.

The significance of these risk estimates can be determined by comparing them with the natural incidence of cancer deaths and genetic abnormalities. Multiplying the estimated exposed worker population of about 1500 persons by the current incidence of actual cancer fatalities (~20%), about 300 cancer deaths are expected (American Cancer Society, 1979). The risk of potential genetic disorders attributable to exposure of the workforce is a risk borne by the progeny of the entire population, and is thus properly considered as part of the risk to the general public. Since BEIR III (1980) indicates that the mean persistence of the two major types of genetic disorders is about 5 generations and 10 generations, in the following analysis the risk of potential genetic disorders from the repair is conservatively compared with the risk of actual genetic ill health in the first 5 generations, rather than the first 10 generations. Multiplying the estimated population within 50 miles of the plant of about 800,000 persons in the year 1986 (CP&L, 1971) by the current incidence of actual genetic ill health in each generation (~11%), about 750,000 genetic abnormalities are expected in the first 5 generations of the population within 50 miles of the plant (BEIR III, 1980).

4.1.1.3 Summary

The NRC staff has reached the following conclusions regarding occupational radiation dose. The licensee's estimate of about 2120 person-rems for the repair at HBR-2 is reasonable. This dose falls within the normal range of annual occupational doses that have been observed in recent years at operating reactors. Although the dose resulting from the steam generator repair will increase the annual occupational dose average of 914 person-rems to approximately 1107 person-rems, this is still well below the 1400 person-rems per reactor annual average which is an upper bound dose average of PWRs experiencing high levels of special maintenance work. The licensee has taken appropriate steps to ensure that occupational doses will be maintained within the limits of 10 CFR Part 20 and the ALARA concept. The additional health risks from these doses over normal risks are quite small, less than 1% of normal risk to the project work force as a whole. The risk to an average individual in the work force will be lower than the risk incurred from participation in many commonplace activities. The individual risks associated with exposures involved in the repair will be controlled and limited so as not to exceed the limits set forth in 10 CFR 20 for occupational exposure. For the foregoing reasons, the staff concludes that the environmental impact from occupational exposure will not significantly affect the quality of the human environment.

4.1.2 Public Exposure

This section contains conservative estimates of the impacts on the public from the proposed steam generator repair project. The major sources of direct radiation and environmental pathways were considered in preparing this section, as shown in Figure 4.1. The section includes doses from radioactive effluents released during the steam generator repair, doses from the storage or disposal of solid radioactive wastes, and the impacts due to solid waste storage.

4.1.2.1 Doses From Effluents

Public radiation exposure from the HBR-2 steam generator repair can be evaluated by comparing the estimated quantities of radioactive effluents from the steam generator repair with annual average releases from normal operations.

The licensee has estimated the amount of radioactivity that will be released in liquid and gaseous effluents as a result of the repair. Those estimates are presented in Table 4.3. The staff has reviewed the licensee's estimates (CP&L, 1971) and concluded that they are reasonable. The expected releases from the repair are less than both the final environmental statement (FES) estimates (NUREG-75/024) and the plant's actual annual releases for normal operations.

On the basis of this comparison, the staff concludes that the offsite environmental impact that may occur during the period of this procedure will be smaller than that which occurs during normal operation.

The staff has estimated the doses to individual members of the public as well as the population as a whole in the area surrounding HBR-2 based on the radioactive effluents which the licensee estimated for the repair (summarized in Table 4.3) and on the calculational methods presented in Regulatory Guides 1.109 and 1.113. The staff estimated the total body dose for an adult at the worst site boundary location, 0.27 mile south of the plant resulting from the release of airborne radioactive effluents during the steam generator repair effort. An airborne release source term of 140 Ci, consisting primarily of Xe-133 and Kr-85 (Table 4.3) and an annual average (ground level continuous release) atmospheric dispersion factor of 4×10^{-5} sec/m^3 (Memorandum, March 14, 1983) were used in these estimates. The total body dose from external gamma radiation for

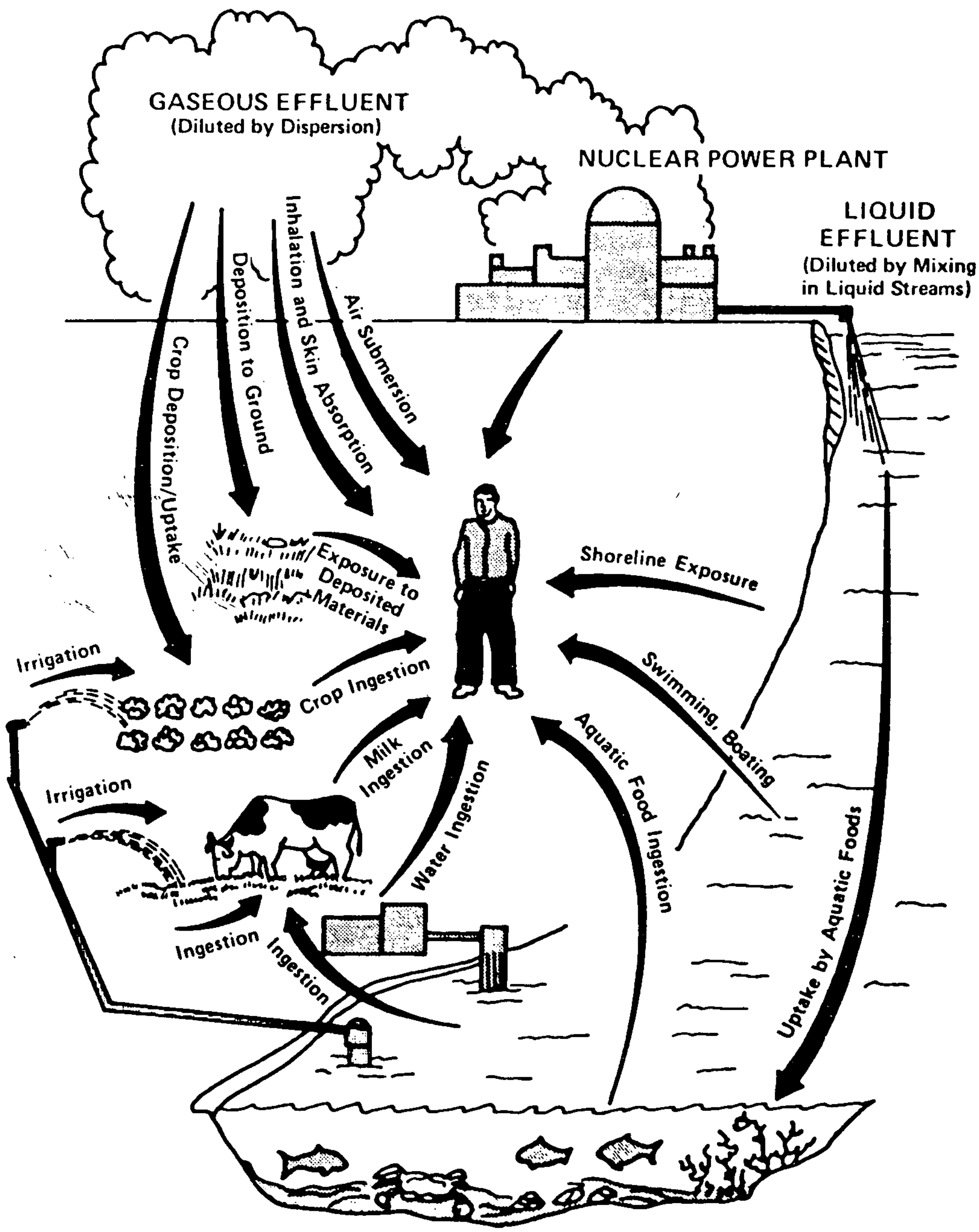

Figure 4.1 Exposure pathways to man

Table 4.3 Radioactive effluents source terms for H. B. Robinson Steam Electric Plant Unit No. 2

Type of radioactive effluent	Surry* actual measurement (Ci/unit)	Turkey Point** estimate (Ci/unit)	Point Beach† estimate (Ci/unit)	H. B. Robinson†† estimate (Ci/unit)	H. B. Robinson source term (Ci/unit)
Gaseous					
Noble gases	100	Negligible	Negligible	140	140
Iodines	7×10^{-7}	1×10^{-2}	7×10^{-6}	4×10^{-5}	4×10^{-5}
Particulates	1.3×10^{-3}	4×10^{-2}	1.5×10^{-4}	9×10^{-5}	9×10^{-4}
Tritium	4.3	Negligible	Negligible	7×10^{-1}	7×10^{-1}
Liquid					
Mixed fission & activation products (excluding tritium)	0.5	0.55	0.23	1.3×10^{-3}	1.3×10^{-1}
Tritium	8.5	185	125	14	14

*NUREG-0692
**NUREG-0743
†Wisconsin Electric Power Company, 1981
††CP&L, 1983.

an adult exposed to a semi-infinite cloud of noble gases at this location was estimated to be less than 4.0 x 10^{-1} mrem. Using a maximum liquid release source term attributable to the repair of 1.3 x 10^{-1} Ci, consisting primarily of Cs-137 (Table 4.3), the staff calculated the maximum individual total body bose for an adult to be much less than 0.01 mrem for the operation. This dose is equivalent to a very small fraction of the limits of 40 CFR 190. The annual limits of 40 CFR 190 are 25 mrem to the total body or any organ except the thyroid and 75 mrem to the thyroid.

The doses to the population of 2.5 million within 50 miles was estimated to be less than 5.7 x 10^{-3} person-rem to the total body from liquid effluents.

By comparison, every year the same population of about 100,000 persons will receive a cumulative total body dose of more than 10,000 person-rems from natural background radiation of about 0.1 rem per year per person. Thus, the population total body dose from the repair is less than one millionth of the annual dose from natural background. On this basis, the staff concludes that the doses to individuals in unrestricted areas and to the population within 50 miles because of liquid effluents from the repair will not be environmentally significant.

In summary, the estimated radioactive releases resulting from the repair are less than those from normal plant operation. The doses from these releases are small compared with the limits of 40 CFR 190 and the annual doses from natural background radiation. Therefore, the radiological impact of the repair will not significantly affect the quality of the human environment.

4.1.2.2 Impacts From Solid Wastes (Not Including Steam Generator Assemblies)

The environmental impact of solid radioactive wastes from the HBR-2 steam generator repair can be estimated by comparing the radioactivity emitted from the quantity of solid waste that will result from the steam generator repair with the annual average releases from normal operations. CP&L (Jan. 6, 1983) has estimated that the steam generator repair efforts will generate about 1700 m^3 of solid waste containing approximately 160 Ci of radioactive material. This value is consistent with the generic report (NUREG/CR-1595) which estimates that 760 m^3 of low activity waste per steam generator would be produced. In the years 1973 through 1982, HBR-2 generated an annual average of about 640 m^3 of solidified radwaste containing approximately 520 Ci (CP&L, 1973 through 1982). Therefore, the radioactive content of the solid waste from the repair will be small compared with the annual amount from normal operations. Since the estimated radioactive content in the solid waste generated by the repair is small in comparison with the amount contained in solid waste from normal operation, the effect of this additional solid waste is not environmentally significant.

4.1.2.3 Impacts From Solid Wastes (Steam Generator Assemblies)

Because the removed steam generator assemblies will be stored in a shielded building on the H. B. Robinson site, there will be no solid waste shipments containing radioactive materials on steam generator components. Ultimate disposal of these steam generator units will be part of the plant decommissioning. At that time, approximately 30 additional years of decay will have reduced the radioactive content significantly.

4.1.2.4 Doses From Onsite Storage of Steam Generator Assemblies

CP&L estimates that each steam generator will contain approximately 300 Ci of fixed gamma radioactivity at the time the steam generators are removed from the containment. The steam generator assemblies will be stored on site in a shielded building. This building will contain sufficient shielding to limit the dose rate to less than 2.5 mrem per hour at the outside of the building. This building is approximately 5000 ft from the nearest site boundary. The staff estimated the additional dose rate at the site boundary to be less than 0.00001 mrem per hour from onsite storage of the steam generators. An individual living an entire year at this location would receive less than 0.1 mrem from this source. This dose rate would decrease rapidly during the first 2 years of storage because short-lived radionuclides would decay; thereafter, the dose would decrease by a factor of 2 every 5 years as the remaining Co-60 decayed. Since these dose estimates represent less than a 0.1% increase in natural background dose and because it is not credible for an individual to camp at the site boundary for great lengths of time, the staff concludes that radiation doses to the public from onsite stored steam generators will be very small and will not be environmentally significant.

4.1.2.5 Effect of Repair on Future Normal Operation

The repair effort will return the plant to the design conditions on which the staff evaluation in the FES (NUREG-75/024) was based. Therefore, the staff concludes that the quantity of radioactive materials released from normal operations after the repair should not be significantly greater than those presented in the FES. Thus, the potential doses to the public and the impact on biota other than man from those materials will be no greater than the doses and impacts presented in the FES.

4.1.2.6 Conclusion

On basis of its review of the proposed steam generator repair, the staff concludes that

(1) The estimated total occupational exposure of 2120 person-rems for the repair is within the expected range of doses incurred at light water power reactors in a year.

(2) The risks to the workers involved in the repair are comparable to the risks associated with other occupations.

(3) The licensee has taken appropriate steps to ensure that occupational dose will be maintained as low as is reasonably achievable and within the limits of 10 CFR 20.

(4) The estimated doses to the general public are:

    (a) much less than those incurred during normal operation of HBR-2, and

    (b) negligible in comparison to the dose members of the public receive each year from exposure to natural background radiation.

4.2 Economic Costs of Steam Generator Repair

Carolina Power and Light Co. has estimated (CP&L, 1983) that the replacement of the three H. B. Robinson steam generator lower assemblies (SGLAs) in the manner proposed in Section 3 will require a total capital expenditure of approximately $102 million (1983 dollars). This cost includes labor, equipment, and other charges such as overhead, contingency funds, and allowance for funds used during construction. The staff believes the cost is reasonable in light of the experience with similar repairs at the Surry and Turkey Point nuclear plants.

The replacement effort is anticipated to require the shutdown of HBR-2 for a period of about 43 weeks, beginning in late May 1984. Normally scheduled annual maintenance, which typically requires 7 weeks, will be performed in parallel with the replacement effort. Therefore, the portion of the total outage time, which can be attributed soley to the replacement effort, amounts to about 36 weeks. Staff views the licensee's estimate of outage time as reasonable in light of the experience gained with other SGLA modifications (Surry and Turkey Point) and compared with a recent projection for the Point Beach Nuclear Plant, Unit No. 1 SGLA replacement effort.

Staff estimates that differential replacement power costs for this additional 36-week outage period are expected to total about $49 million (1983 dollars). This dollar amount reflects the differential fuel cost derived by subtracting the average $5 per MWh cost of energy produced by the HBR-2 from the average $25* per MWh cost of energy from projected sources of replacement power (primarily from the coal-fueled plants in the licensee's system). A major assumption in calculating this cost is that the unit could operate at its current maximum capability--70% of its design electrical rating (DER)--throughout the outage period. This assumption is somewhat optimistic. At the current rate of corrosion, tube degradation will continue causing further reductions (deratings) in maximum dependable capacity from the unit. Although these deratings are not anticipated to be substantial for the additional 36-week period, the replacement cost differential calculated above and based on the projected amount of energy to be replaced can be considered conservative (high) in view of these deratings.

In summary, the total cost of the replacement effort is projected to be $151 million (1983 dollars)--the sum of the capital investment and the replacement power costs.

4.2.1 Nonradiological Environmental Costs

Socioeconomic impacts will be small and generally beneficial. No effects on historic or archeological resources are anticipated.

4.2.2 Construction Cost Impacts

Socioeconomic impacts associated with changes in the natural and physical environment will be negligible. Socioeconomic impacts associated with up to 1000 personnel required over approximately 43 weeks will be generally small and beneficial to the region. A large portion of the work force will be hired from within daily commuting distance.

*This cost is based on the cost of coal fuel to the licensee of about $1.93 per million Btu in December 1982 (U.S. Department of Energy, 1982).

No known historic or archeological resources exist on the portion of the site affected by the project.

4.3 Nonradiological Environmental Assessment

4.3.1 Construction Impacts

Nonradiologically related construction activities have been evaluated for their potential to impact both aquatic and terrestrial species occurring at the H. B. Robinson site (see Figure 4.2). The following presents a discussion of these activities and an assessment of their potential impact on organisms inhabiting the site.

The repair involves removal of the lower steam generator assemblies and replacing them with new assemblies which will be shop fabricated and delivered to the site ready for installation. Before dissassembly and removal of the existing assemblies, the steam generators will be washed with solvents to decontaminate them. The new steam generator sections will be brought in by rail, and a temporary railroad spur will be constructed on site to provide temporary storage. Related facilities to be built include a permanent maintenance building. Additionally, there will be minor foundation work in the immediate vicinity of the containment building.

All construction activities associated with the steam generator repair will take place within the security fence, on sections of the site used as laydown storage areas during original plant construction. Some of these former construction areas will have to be recleared. The method for ultimate disposal of the old steam generator assemblies has not been selected. It is likely that they will be stored on site in a concrete vault for the life of the plant.

Such temporary nuisances as erosion, dust, and noise often associated with construction will be confined to a much smaller area and will be of much shorter duration than experienced with initial construction. Although the outage for repair should be less than 270 days, the licensee will pave or spray the roadways to abate dust. The licensee has projected that noise at the site boundary from the steam generator replacement activities will not exceed noise experienced during the most recent outage.

The usage rate of water for HBR-2 during the replacement outage will be less than during normal operation. Sanitary waste treatment facilities for the site are being expanded for reasons unrelated to the steam generator replacement. Portable units will supplement this expanded waste treatment system during the construction period.

Processing of decontamination wash and rinse solutions will be dictated by radiological considerations. Generally, waste streams resulting from decontamination are expected to be "processed as appropriate and drummed for off-site disposal" and no discharge to surface or groundwater will occur. The contamination to be removed from the steam generators before disassembly is primarily the metallic activation products in a thin film of oxides on internal surfaces. The oxides are generally regarded as magnetite. The wash solutions for removing the metallic film have not yet been selected. They are to be proposed by potential contractors. The licensee will approve the cleaning solutions as part of

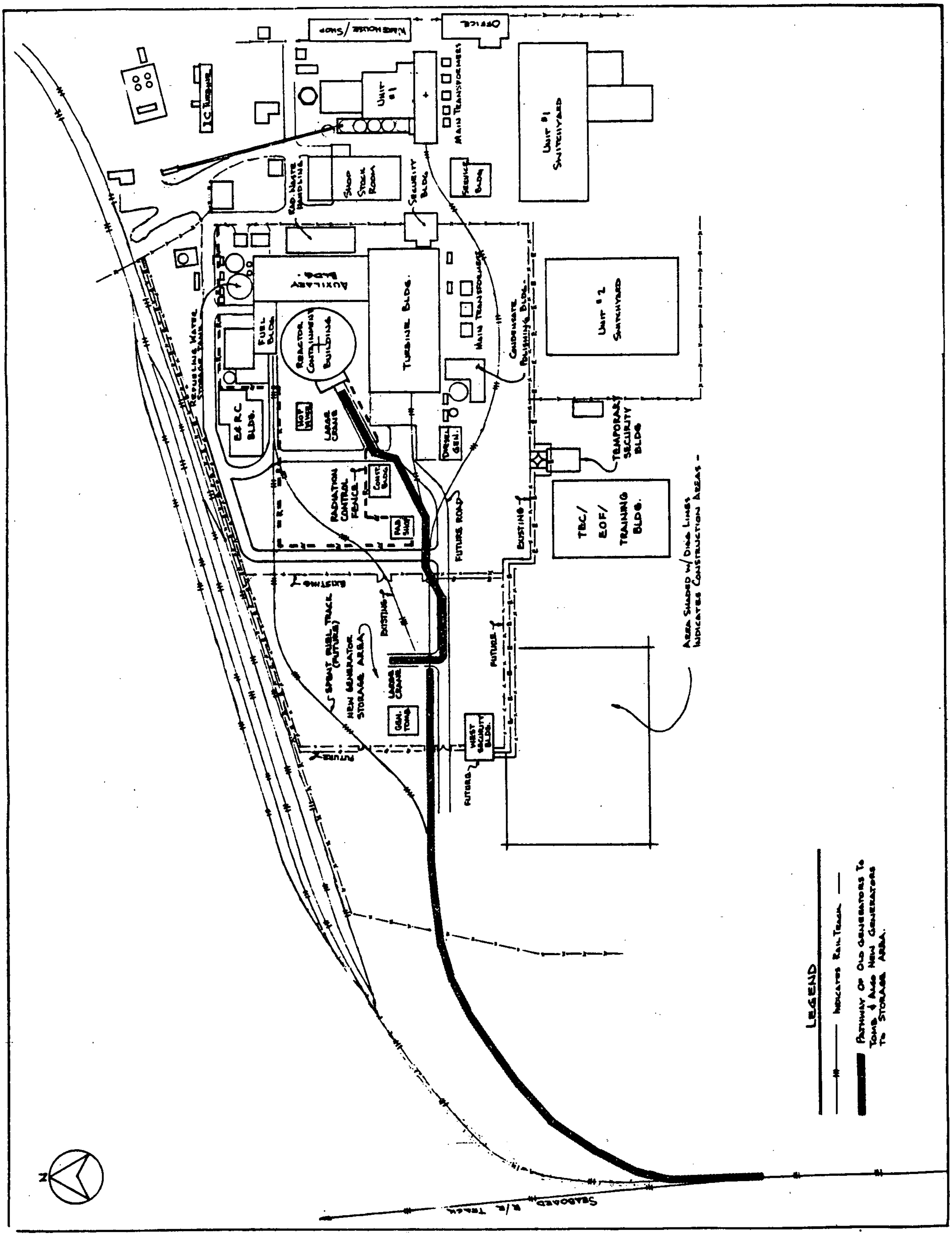

Figure 4.2 H. B. Robinson plant site

its process for selecting a contractor. Although cleaning solutions are usually proprietary and thus not precisely identified, they all contain complexing agents to bind metal in solution. Because the metal oxides picked up in the wash have some radioactivity, no discharge will be made. Although NRC regulations would permit discharge if activity were very low, such discharge should be subject to State review and approval. The licensee has indicated that the steam generator replacement will not require any change to the National Pollutant Discharge Elimination System (NPDES) discharge permit.

Because all activities will take place on previously cleared areas and because all discharges will be consistent with the terms of the current NPDES discharge permit, it is concluded that construction activities associated with the steam generator repair program will not have a significant adverse impact on natural resources of the site and vicinity.

4.3.2 Operational Impacts

When the station is returned to service, the licensee expects secondary system water consumption during normal operation to be considerably less than during previous operation. Currently leaking condenser tubes cause frequent shutdowns, which wastes high purity water. After the repair less high purity water will be wasted although changes are being made to water treatment systems to afford better control of water chemistry that may at times require somewhat higher flow. The steam generator makeup and blowdown systems are being modified to permit higher makeup and blowdown rates during startup and other periods when steam generator chemistry requirements so dictate.

A full-flow condensate polishing demineralizer system is being installed to further control the chemical quality of secondary water. Treatment systems to process regenerants and waste effluents for reuse or disposal will also be added. The licensee is also adopting all volatile treatment in lieu of phosphate treatment to control corrosion. This will result in the discharge of small amounts of organic materials instead of the small amount of phosphates in the steam generator blowdown. The licensee expects steam generator blowdown flow rate normally will be about at the same rate (25 gpm per generator) as before replacement. As indicated above, during certain periods necessitated by chemical quality considerations, flow will be somewhat higher. As before the repairs, steam generator blowdown is monitored for radiation and, if acceptable, is discharged to the cooling lake without further treatment. No NPDES discharge permit modification is necessary for these design changes, according to the licensee.

Since the changes in operation of the secondary cooling system are small with regard to discharge and since such changes are within the bounds of the current NPDES discharge permit, the environmental effects of operation after restart will not be significantly greater or different from those previously reviewed and analyzed in the FES.

4.3.3 Endangered Species

Since all activities associated with steam generator replacement will take place within the security fence on site areas previously disturbed for initial plant construction and since there is no significant change in station waste discharges, endangered species will not be directly affected by the replacement program. A colony of red cockaded woodpeckers has been identified on the licensee's property well outside of the security fence. This colony appears to be co-existing with the industrial usage of the property. The stresses to the woodpeckers from the stream generator replacement program are believed to be within the envelope of other stresses of power generation activities at the site and, therefore, no impact is expected.

4.4 Environmental Impact of Postulated Accidents

The design and plant operating parameters that are relevant to accident analyses will not change as a result of a steam generator repair effort. Therefore, the assessment of the environmental impact of postulated accidents presented in the FES of April 1975 (NUREG-75/024) will be unchanged and remains valid.

The safety evaluation also considers accidents that are unique to the repair effort. The accidents considered were accidents that occurred during cutting operations and lifting accidents inside and outside of containment, both from the point of view of damage to the steam generator itself and to nearby components and structures. All the accidents were evaluated with large factors of conservatism. The one with the largest calculated dose was found to be release of activity following the drop of the steam generator outside of the containment building.

About 31 Ci of radioactive materials could be dislodged if the welded end plate over the primary side of the steam generator failed during the drop. The staff estimated that a release of half of the "loose" activity might occur. The limiting potential receptor from the point of view of both breathing rate and dose conversion factors is the teenager's lung. Average meteorological conditions were postulated, and the potential receptor was assumed to be at the exclusion area boundary. The radiological consequence evaluated for these conditions is a dose of about 0.1 mrem. Several areas of conservatism are present in this evaluation: (1) the drop accident itself is unlikely, (2) it is unlikely that the welded end plate could completely fail, and (3) the amount of activity that was considered to be dislodged and released to the environment was conservatively estimated.

Some amount of activity, primarily Co-60, would probably be carried to the site boundary and deposited as "contamination" in case of an actual accident. It is not possible to evaluate quantitatively the amount of activity that actually might be transported to the boundary, mainly because the effects of the factors of conservatism listed above cannot be evaluated. It is the staff's judgment, however, that the amount would be acceptably small.

Compliance with staff guidelines related to postulated accidents involving steam generators is discussed in the Safety Evaluation Report (NUREG-1004, to be published). For the purposes of assessing the environmental impact of accidents, the staff has compared the environmental impact of an accident with 10 CFR 20, which is applicable to normal operation, and concluded that the consequences of accidents are comparable to those allowed during normal operation. The combination of the potential environmental impact with the probability of occurrence of accidents results in a risk to the public that is acceptably small.

5 ALTERNATIVES TO THE PROPOSED ACTION

The basic options for future action regarding the H. B. Robinson steam generator tube degradation problems are (1) replacing the steam generators' deteriorating lower assemblies as proposed, (2) entirely replacing the three steam generators, (3) retubing the steam generators in place, (4) sleeving the steam generator tubes, or (5) shutting down the unit and replacing its energy by using CP&L existing generating units and/or by intersystem purchases. CP&L has opted to immediately replace the lower assemblies of the unit's three steam generators (alternative 1), and to make changes in design, materials, and operating procedures calculated to eliminate the future occurrence of tube degradation problems.

The following sections consider the benefits and costs associated with the above alternatives using alternative 1 as the base case. Sections 4.1 and 4.2 describe the radiological and economic impacts associated with alternative 1.

5.1 Alternative 2: Entirely Replacing the Steam Generators

Entirely replacing the steam generators is not a reasonable alternative to the proposed method of repairs because of space and handling limitations within the containment structure. There is insufficient laydown area within the containment building to accommodate an entire steam generator, and it is questionable whether the existing polar cranes can be upgraded to lift the 355-ton weight of a steam generator. Even if upgrading were possible, there is insufficient "head room" to provide the clearance required to lift the steam generators. Therefore if the steam generators were to be replaced, the structural integrity of the containment building would have to be breeched by cutting an access hole in the dome of the building large enough to accommodate the steam generator. In addition, special exterior cranes would have to be constructed to lift the units from the containment.

Because of the inordinate amount of structural modification required for removal and the internal limitations for positioning the steam generators, the staff feels that entire replacement of the steam generators is not a viable alternative.

5.2 Alternative 3: Retubing the Steam Generators in Place

Another alternative to the proposed plan is to retube the generators while they remain in the containment building, as described by the Westinghouse Nuclear Energy System Group in "Steam Generator Retubing and Refurbishment" (WCAP-9398). At present, no major commercial reactor has undergone such a modification; however, this or a similar technique may be used in the future. Current projections (NUREG/CR-1595) indicate that occupational dose associated with this repair technique is expected to be approximately 2300 person-rems per steam generator. The licensee's proposed modification program is expected to result in approximately 806 person-rems per steam generator or about one-third the exposure of the retubing method. In addition, retubing the steam generators in place would increase the difficulty of implementing the full spectrum of the proposed design improvements incorporated in the new SGLAs, which in turn would probably result in a more exposure-intensive operation. The staff views the proposed alternative as the most favorable.

5.3 Alternative 4: Sleeving the Steam Generators

The tube sleeving concept and design are based on observations that tube degradation from caustic attack occurs primarily in the tubesheet crevice region. The sleeves are designed to span the degraded regions for those tubes that have already suffered damage and for those that are more likely to suffer damage. Experience has shown that the tubes in the central regions of the steam generators are most likely to suffer damage. Thus, the sleeving alternative envisions sleeving only about half of the steam generator tubes.

In evaluating the sleeving alternative, the licensee made certain assumptions which are summarized as follows:

(1) The sleeving alternative would only postpone the need for the proposed SGLA replacement for about 2 to 6 years, at which time the currently proposed replacement program or a similar program will be required.

(2) Tube inspection would be required approximately every 3 months of operation.

(3) NRC would authorize operation at 95% of full rated power.

(4) The sleeves would be installed during a 12-week scheduled outage in 1984.

The capital costs of the sleeving alternative is estimated at about $172 million (1983 dollars) or about $21 million more than the proposed replacement plan. This cost includes the approximately $67 million (letters, July 14 and 25, 1983), of capital already "sunk" in the proposed plan.

The sleeving and "sunk" costs above do not include repair costs subsequent to the sleeving operation. Also excluded is the additional cost of replacement power which will be incurred as a result of the additional time required during each scheduled maintenance outage for tube inspection and plugging during the remaining lives of the steam generators. Staff estimates differential replacement power costs to total approximately $1.3 million (1983 dollars) per week.

After the 2 to 6 years of extended operation afforded by the sleeving alternative, the plant availability may be adversely impacted by further degradation of the steam generators (assuming the SGLAs are not replaced). However, the effects are not anticipated to be as severe as the impact produced under alternative 5, which follows. The 2-to-6-year lead time would give the licensee some time to either install additional facilities or negotiate for sufficient purchased power.

In addition to the greater monetary costs of the sleeving alternative, person-rem exposures under the sleeving option are anticipated to be higher. In the proposed plan a total of approximately 2420 person-rems are expected; the sleeving alternative will produce approximately 3970 person-rems, or a 60% greater exposure. Considering the greater monetary costs, greater radiological exposure, and limited benefit of the sleeving alternative, the staff's view is that the proposed alternative 1 is preferable.

5.4 Alternative 5: Shutting Down H. B. Robinson Unit No. 2 and Relying on Licensee's Existing Generation

Unlike the previously considered alternatives, alternative 5 involves no immediate capital cost expenditure with the exception of the $67 million sunk costs already incurred under the proposed plan. A cost analysis was performed by CP&L which compared system costs under alternative 1 (the proposed plan) and alternative 5. Under alternative 5 HBR-2 would be shut down on December 31, 1984.

The licensee has estimated that based on the history of tube plugging and at the current level of tube plugging, approximately 300 plugs per year, the units will have to be retired in December 1984 because (1) of reduced heat transfer area within the steam generators, and (2) with increased tube plugging, the operating time between inspections would be too short to justify continued operation.

The comparison of this alternative with the proposed plan includes all applicable costs, both capital and other costs (including production, decommissioning, and nuclear insurance costs) for the 15-year study period 1984 through 1998. For purposes of the comparison it was optimistically assumed (see Section 4.2) that HBR-2 could continue to operate at basically the same level as is currently being experienced, which is at approximately a 70% operating capacity factor* and a steam generator inspection outage every 3 months through 1984. The unit would then be retired on December 31, 1984. This scenario was compared with the proposed plan which reflects a return to full-power operation and an 85% operating capacity factor* after replacement of the SGLAs. Over the remaining life of the plant, this operating capacity factor translates to a 60 to 65% annual capacity factor.

The result of the licensee's cost comparison indicates that premature retirement of HBR-2 will result in a net cost of $348 million (1983 dollars) to the CP&L system during the period 1984 through 1998.

The staff estimates that the economic penalty of the December 1984 shutdown of HBR-2 will total over $62 million per year (1983 dollars). Thus the estimate of $151 million for the steam generator repair will be recovered in less than 3 years. Over the 15-year period 1984 through 1998, staff estimates that accumulated annual savings (or cost avoided) resulting from the proposed replacement plan will total over $600 million (1983 dollars). Therefore the staff views the CP&L estimate of $348 million as understating the economic advantage of the proposed replacement program.

Although the immediate shutdown would result in a reduction in potential exposure of about 11,000 person-rems during the study period (maintenance and refueling), this reduction must be balanced against the $348 million cost penalty associated with shutdown.

*Operating capacity factor is an average capacity factor which excludes periods of scheduled outage.

The retirement of HBR-2 under alternative 5 would leave the CP&L system with insufficient generating capacity. Construction of generating units planned or anticipated for the future would have to be accelerated to make up the deficiency created by the retirement of HBR-2. Inclusion of the cost of replacement generating capacity would further increase the margin of savings in HBR-2 retirement, resulting in increased savings from continued operation of HBR-2 after replacement of the SGLAs in 1984.

The licensee states that the increase in fossil fuel usage over the 1984 through 1998 study period would be approximately 16 million tons of coal, 3 million cubic feet of natural gas, 7 million gallons of oil, and 33 million gallons of propane. The staff concludes that based on the cost differential, the environmental consequences of increased fossil fuel consumption and the uncertainty of power available for purchase, the proposed alternative is preferred.

5.5 Summary of Alternatives

Table 5.1 summarizes the economic and radiological costs of the various alternatives discussed. These costs are supplemented by qualitative assessments which attempt to characterize the major advantage and/or drawbacks of each alternative. Comparing the economic and exposure costs of these alternatives and giving due regard to the qualitative evaluation, the staff concludes that the replacement plan selected by CP&L (alternative 1) is the best of the available alternatives.

5.6 Decontamination and Disposal of the Steam Generators

The proposed plan for replacement and disposal of the lower assemblies of H. B. Robinson steam generators is discussed in Section 3. The following sections discuss (1) methods under consideration to reduce exposure levels in and around the areas in which the proposed modification will take place, and (2) the radiological and economic costs of alternative methods of disposal of the removed assemblies.

5.6.1 Decontamination

The licensee states (CP&L, 1983) that two levels of decontamination will be employed in the replacement project. During the initial stages of the project, a general area decontamination will be performed. A second primary surface decontamination will be performed on high exposure rate components such as the steam generator channel head.

With the general decontamination of the containment building, most of the exposed surfaces in task-related areas will be cleaned. The removal of much of the radioactive surface contamination will decrease the potential for the spread of contamination to clean areas, and lessen the chances for personnel and equipment contamination incidents.

With primary surface decontamination, specific decontamination will be performed on high exposure rate components such as the steam generator channel head. In the channel head cut approach, some decontamination of the channel head region of the steam generators would be advantageous in maintaining exposures to a minimum. The interior surface of the channel head will probably be decontaminated by some remote means before the final cut separates the lower shell

Table 5.1 Comparison of alternatives

Alternative	Economic penalty in millions (1983 $)	Exposure (person-rem)	Comment
1 Proposed replacement plan	Base	2420	Minimum inspection or repairs required in the future.
2 Replace steam generators	NA	NA	Integrity of containment compromised.
3 Retube steam generators	NA	6900*	No commercial application of this technique has been made to date.
4 Sleeve	21	3970	Considerable inspection, repairs, and replacement power required. Eventually, SGLA must be replaced.
5 Continue operation in the present mode	348	NA	Based on current rate of degradation, unit would be shut down giving no long-term benefit.

* NUREG/CR-1595.
NOTE: NA = not available.

assembly from the channel head. Appropriate blocking devices will be placed in the reactor coolant pipe before the decontamination takes place. The person-rems expended in the decontamination effort will be balanced against the potential person-rem savings incurred during the removal operations.

Two different decontamination methods are presently being evaluated for primary surface decontamination. They are:

(1) Fill and Soak - This would involve filling the primary side of the steam generator with a suitable decontaminating solution and allowing sufficient soak time for the solution to work. This soak would be followed by a rinse of the primary side. The liquid waste would be processed as appropriate and run into drums for offsite disposal.

(2) Mechanical - A wet abrasive grit would be sprayed at a high velocity against the area to be decontaminated. This method removes the surface layer of the metal that contains the radioactive contamination. The abrasive, surface contamination, and corrosion products are filtered out of the wet slurry and drummed for offsite disposal. The liquid steam would be processed as appropriate and drummed for offsite disposal. This method was used at San Onofre Unit 1 and Turkey Point Unit 3.

Radiation dose to workers from decontamination efforts can vary depending upon the process. The staff views both methods under consideration for primary surface decontamination to be equally effective, with exposure levels in the range 5 to 60 person-rems to be expected from either method. References NUREG/CR-2963 and NUREG/CR-1595 give more detailed information on decontamination methods.

5.6.2 Alternative Disposal Methods

CP&L identified five disposal alternatives for the steam generator lower assemblies once they are removed from containment. These alternatives are presented in Table 5.2 along with licensee's estimates of economic and person-rem costs.

Table 5.2 Disposal alternatives: Economic and radiological costs

Alternative	Applicant's cost estimate 1983 dollars	Person-rems
1 Immediate intact offsite shipment without decontamination	2,870,000	30-50
2 Immediate intact offsite shipment without decontamination	3,361,000	40-70
3 Long-term intact onsite storage	2,858,000	10-20
4 Immediate cut-up and offsite shipment with decontamination	5,396,000	175-350
5 Immediate cut-up and offsite shipment without decontamination	5,637,000	550-1650

NUREG/CR-1595 discusses the radiological costs of several alternative methods for disposing of removed steam generators. This discussion is summarized in Table 5.3. The licensee's estimates of person-rem exposure under each alternative compare favorably with the Table 5.3 estimates.

Based on a comparison of the economic and person-rem costs of these five alternatives (Table 5.2), alternative 1, immediate intact offsite shipment without decontamination, and alternative 3, long-term intact onsite storage, seem best. The licensee plans to proceed with onsite storage of the steam generators. This would still allow CP&L to proceed with alternative 1 should future conditions enhance its desirability.

Table 5.3 Steam generator disposal alternatives of NUREG/CR-1595

Alternative	Approximate person-rems/SG	Approximate airborne release, Ci/SG
Long-term* storage (including surveillance) with intact shipment	10	Negligible**
Long-term* storage with cut-up and shipment	16	0.005
Shorter storage with cut-up		
at 5 yr	230	0.026
at 15 yr	60	0.015
Immediate intact shipment	2.4†	Negligible**
Immediate cut-up and shipment by rail/truck - no decontamination	580	0.042
Immediate cut-up and shipment by rail/truck - with chemical decontamination	270	0.010

*30 to 40 years.

**Since the steam generator will be sealed before it is removed from containment, no release of radioactive material is expected during the repair operation.

†Estimates for short-term storage followed by intact shipment would be only slightly larger than this, perhaps 5 person-rems.

6 CONCLUSIONS

The staff has reviewed the proposed steam generator repair action and has reached the following conclusions:

(1) The proposed replacement of the lower assemblies of the steam generators is the best available option, from both the radiological and economic standpoint, for eliminating the tube degradation problem.

(2) The dose reduction measures to be used by the licensee have been reviewed by the staff, with the conclusion reached that the doses would be ALARA. The health effects resulting from such exposure have also been considered and it is concluded that these are not significant.

(3) The new steam generator design incorporates features that will eliminate the potential for the various forms of tube degradation observed to date.

(4) The restoration would return the generators to the condition evaluated in the FES (NUREG-75/024).

(5) Offsite doses resulting from the steam generator repair will be less than those from recent plant operations, comparable with doses presented in the FES (NUREG-75/024), and small compared with the annual doses from natural background radiation. Therefore, the offsite doses will not be significant.

Balancing the costs of the proposed action, both environmental and economic, against the benefits of the continued safe production of power for the public, the staff concludes that the benefits of the proposed project outweigh the costs. The overall cost benefit would not be improved by any of the alternatives.

On the basis of the foregoing analysis, the staff concludes that the proposed steam generator repair will not adversely impact the quality of the human environment.

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8 FEDERAL, STATE, AND LOCAL AGENCIES TO WHOM THIS DRAFT ENVIRONMENTAL STATEMENT WAS SENT

This Draft Environmental Statement was sent to the following:

Advisory Council on Historic Preservation
Carolina Power and Light Company
Darlington County
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Energy
Department of Health and Human Services
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Environmental Protection Agency
Federal Emergency Management Administration
Federal Energy Regulatory Commission
State of South Carolina

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16. ABSTRACT *(200 words or less)*
The staff has considered the environmental impacts and economic costs of the proposed steam generator repair at the H. B. Robinson Steam Electric Plant Unit No. 2 along with reasonable alternatives to the proposed action. The staff has concluded that the proposed repair will not significantly affect the quality of the human environment and that there are no preferable alternatives to the proposed action. Furthermore, any impacts from the repair program are outweighed by its benefits.

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